



華中科技大學

HUAZHONG UNIVERSITY OF SCIENCE AND TECHNOLOGY

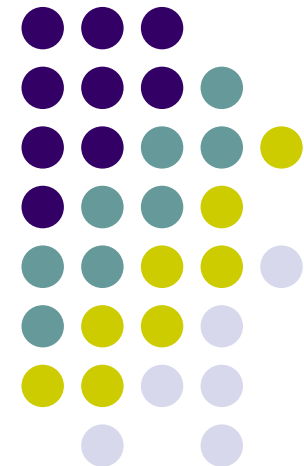
Characteristics of ion debris from laser produced tin plasma in ambient gas and magnetic field

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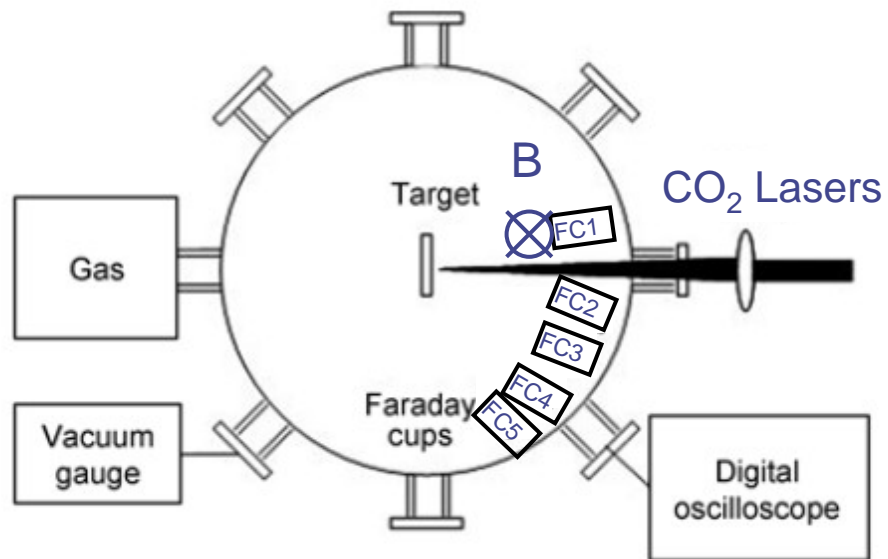


Introduction



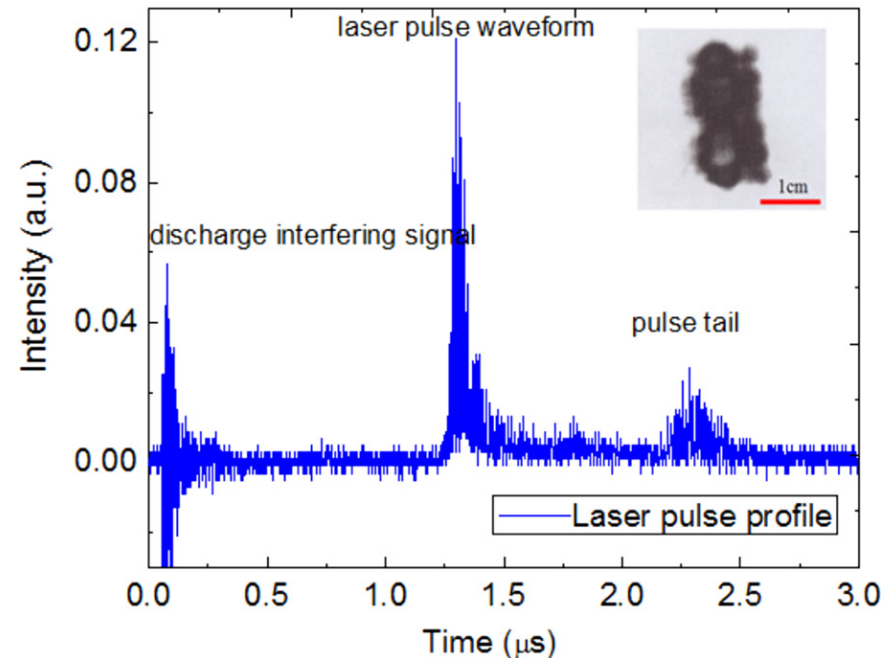
In this paper the ion debris measurements were carried out in the presence and absence of magnetic field using Faraday cup array. A TEA CO₂ laser was used to produce the plasma, and the IRD photodiode was used for EUV detection. To measure ion debris distribution, 5 Faraday cups were placed at a distance 12 cm from the target surface, equally spaced at an angle of 18°. The ambient magnetic field was supplied by an assembly of 2 permanent magnets creating a nearly uniform field configuration before the one Faraday. Our initial experimental results indicated that the ion kinetic energy and ions yield can be reduced by H₂ buffer gas from the pressure of 10 to 1000 Pa. While magnetic field (in our case the intensity of the magnetic field is about 0.8T in the surface) will deflect propagation direction of ions, and reduced the FC signal perpendicular to the target. Our results show that buffer gas combined with the magnetic field is an effective way to reduce the ion debris.

● Experimental setup



5 Faraday cups were placed at a distance 12 cm from the target surface, equally spaced at angle of 18° with respect to the surface normal. FC1 and FC2 are symmetrically at the laser beam, and 2 permanent magnets were placed before FC1.

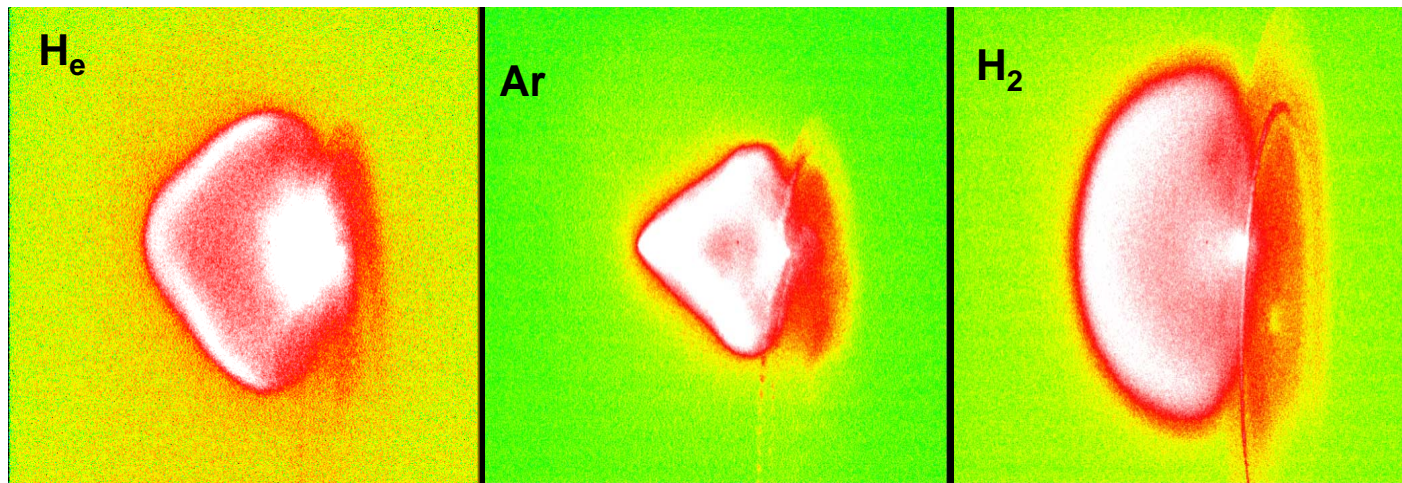
CO₂ laser parameters:



Pulse energy: 400 mJ

FWHM: 75 ns

●CO₂ Laser Produced Solid Tin Plasma---- plasma expansion



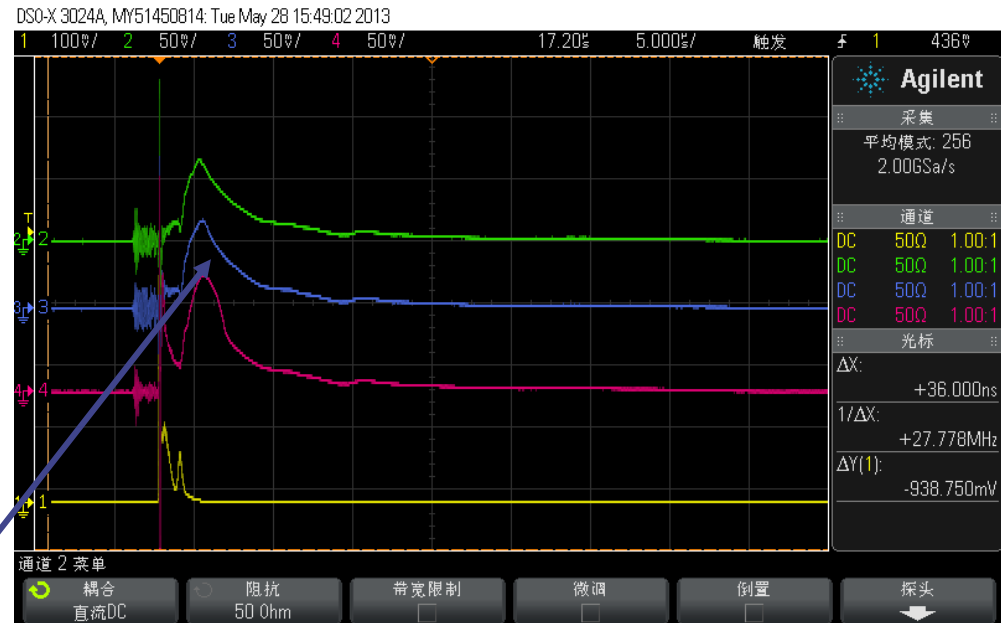
Plasma expansion in H₂, H_e and A_r buffer gas

●CO₂ Laser Produced Solid Tin Plasma---FC signal



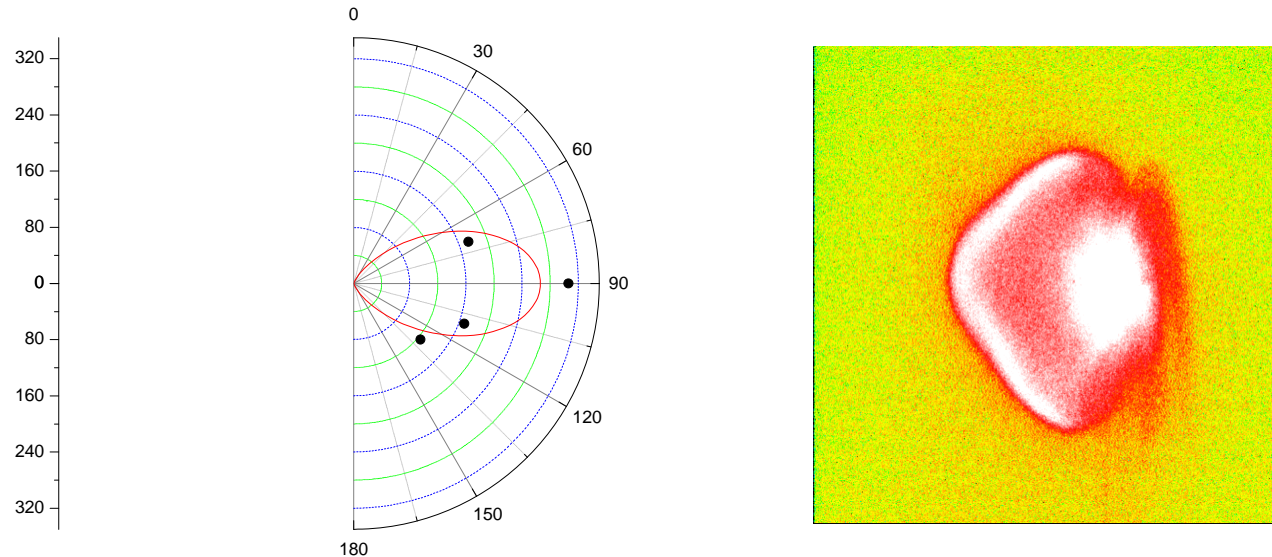
Self made FCs

Laser reheating of the target



FC signal (green, blue ,red line),the yellow line is the laser pulse

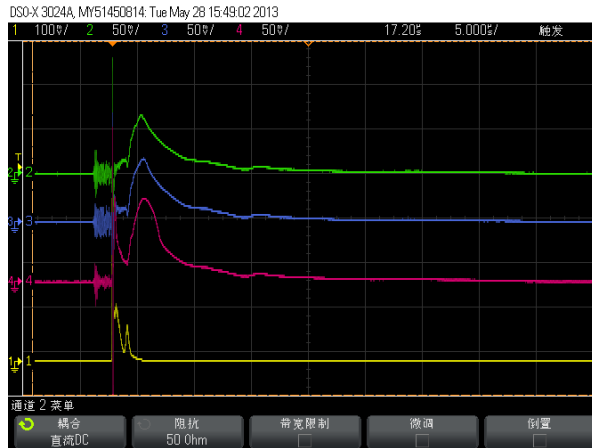
●CO₂ Laser Produced Solid Tin Plasma---- ion debris distribution in Ar



Angular distribution of integral of the FC signal in Ar buffer gas with magnetic field, fitted curve is

$$\cos \theta^{4.1}$$

●CO₂ Laser Produced Solid Tin Plasma---- Influence of FC signal in magnetic field



Gas pressure 10⁻³ Pa

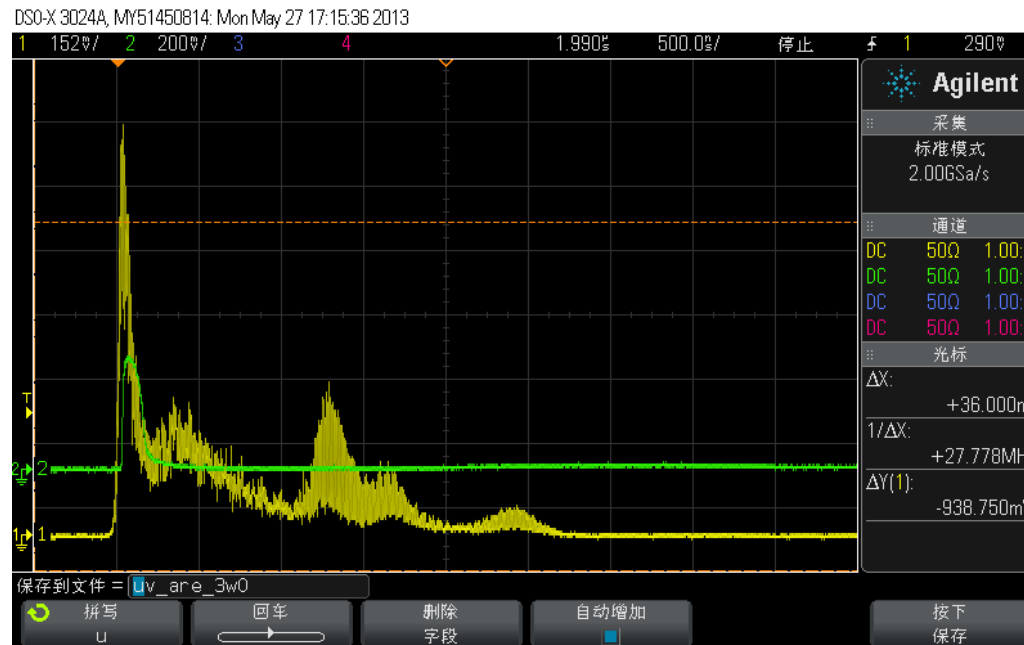
FC1 signal with magnetic field (green line), FC2 signal (red line),
FC3 signal (blue line)



Gas pressure 10 Pa

- Magnetic field can reduce the FC signal in low pressure
- At high buffer gas pressure(>10 Pa) the influence of magnetic field on FC signal is weak

●CO₂ Laser Produced Solid Tin Plasma---- EUV radiation



EUV radiation
signal in **IRD
photodiode** (green
line), yellow line is
the laser pulse

CO₂ laser tail has no contribution to the EUV radiation

●CO₂ Laser Produced liquid Tin Plasma---tin droplet generation

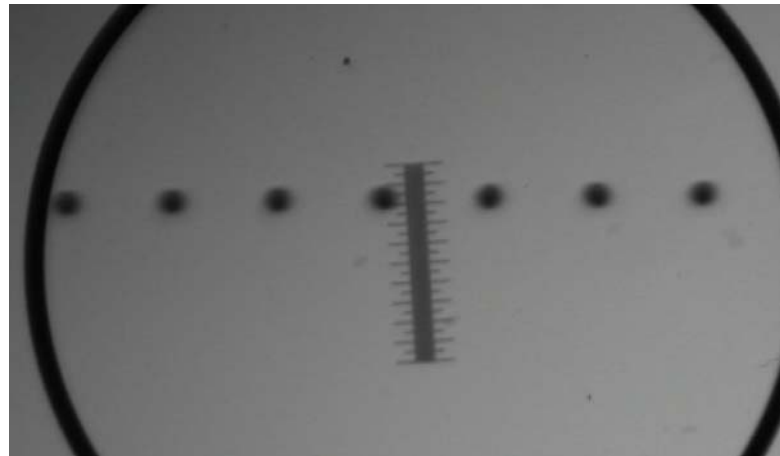
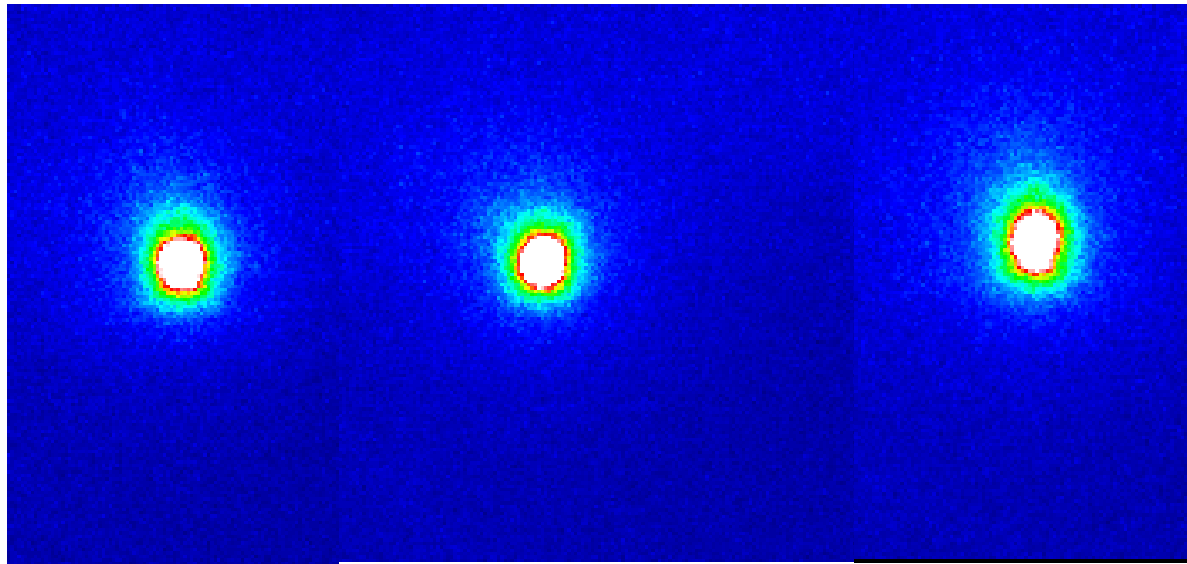


Image of the water droplet, droplet diameter is about 100 μm , droplet frequent is about 20 kHz.

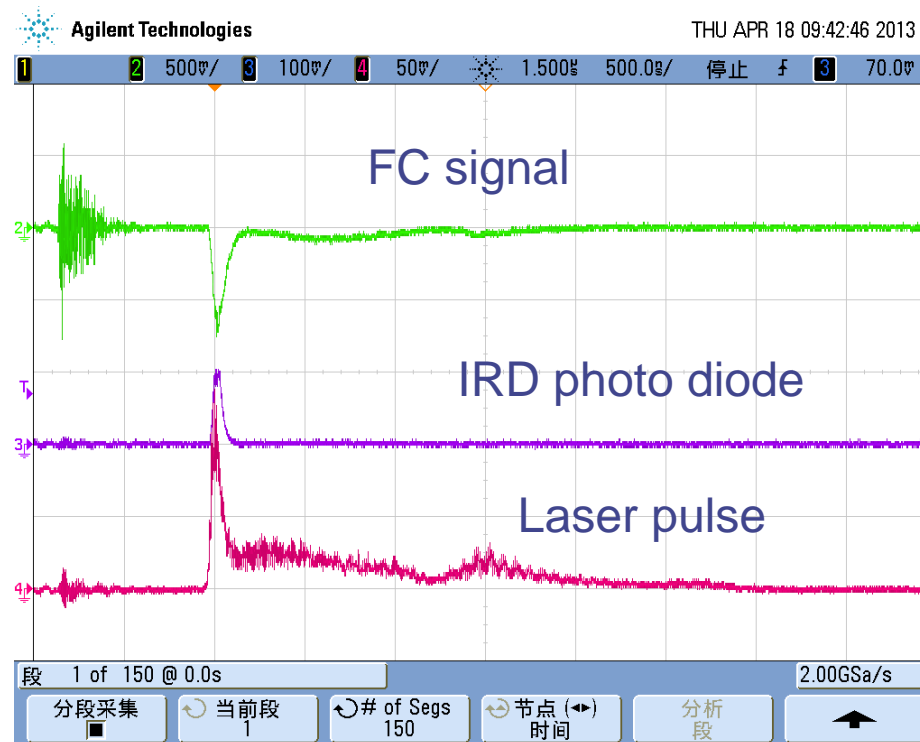
●CO₂ Laser Produced liquid Tin Plasma----

Plasma expansion



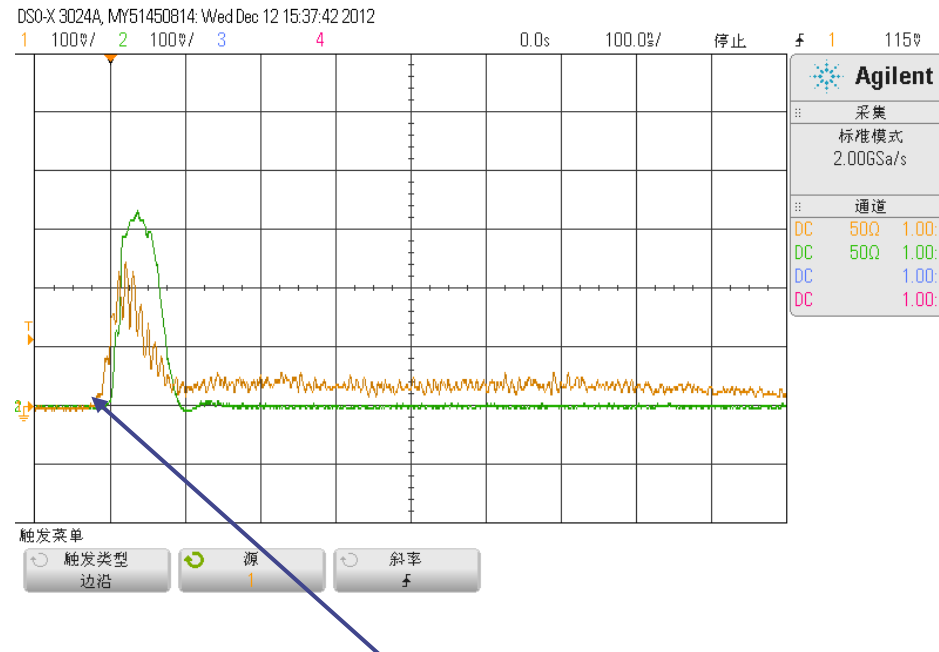
ICCD image of tin plasma plume for a time delay of 2 μ s after pulse discharge with a gate width of 50 ns.

●CO₂ Laser Produced liquid Tin Plasma---FC signal



FC signal is weak in laser produced tin plasma, no reheat effect in tin droplet target

●CO₂ Laser Produced liquid Tin Plasma---- EUV radiation



About 20 ns delay after laser bombed the tin droplet

EUV radiation signal in **IRD photodiode** (green line), yellow line is the laser pulse

●Conclusions

- **CO₂ Laser Produced Solid Tin Plasma**

1. Magnetic field can reduce the FC signal in low pressure
2. At high buffer gas pressure(>10 Pa) the influence of magnetic field on FC signal is weak
3. The CO₂ laser pulse tail will reheat the tin target to produced more ion debris, and has no contribution to EUV radiation

- **CO₂ Laser Produced Tin droplet Plasma**

- FC signal is weak in laser produced tin droplet plasma, no reheat effect in tin droplet target
- The CO₂ laser has no contribution to EUV radiation, The delay between the CO₂ laser pulse in EUV radiation is about 20 ns, which is similar in the case of solid tin target.

- **Fucture work**

1. Our self made FC needs to improve.
2. More research should be done in laser produced tin plasma.

